Technologies for the First Interstellar Explorer: ***Beyond Propulsion***

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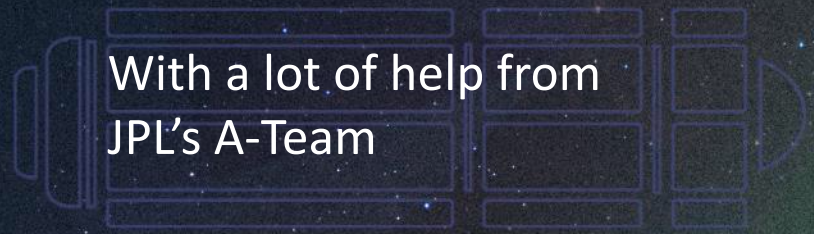
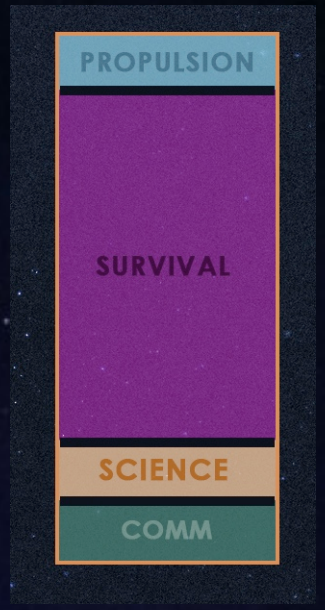
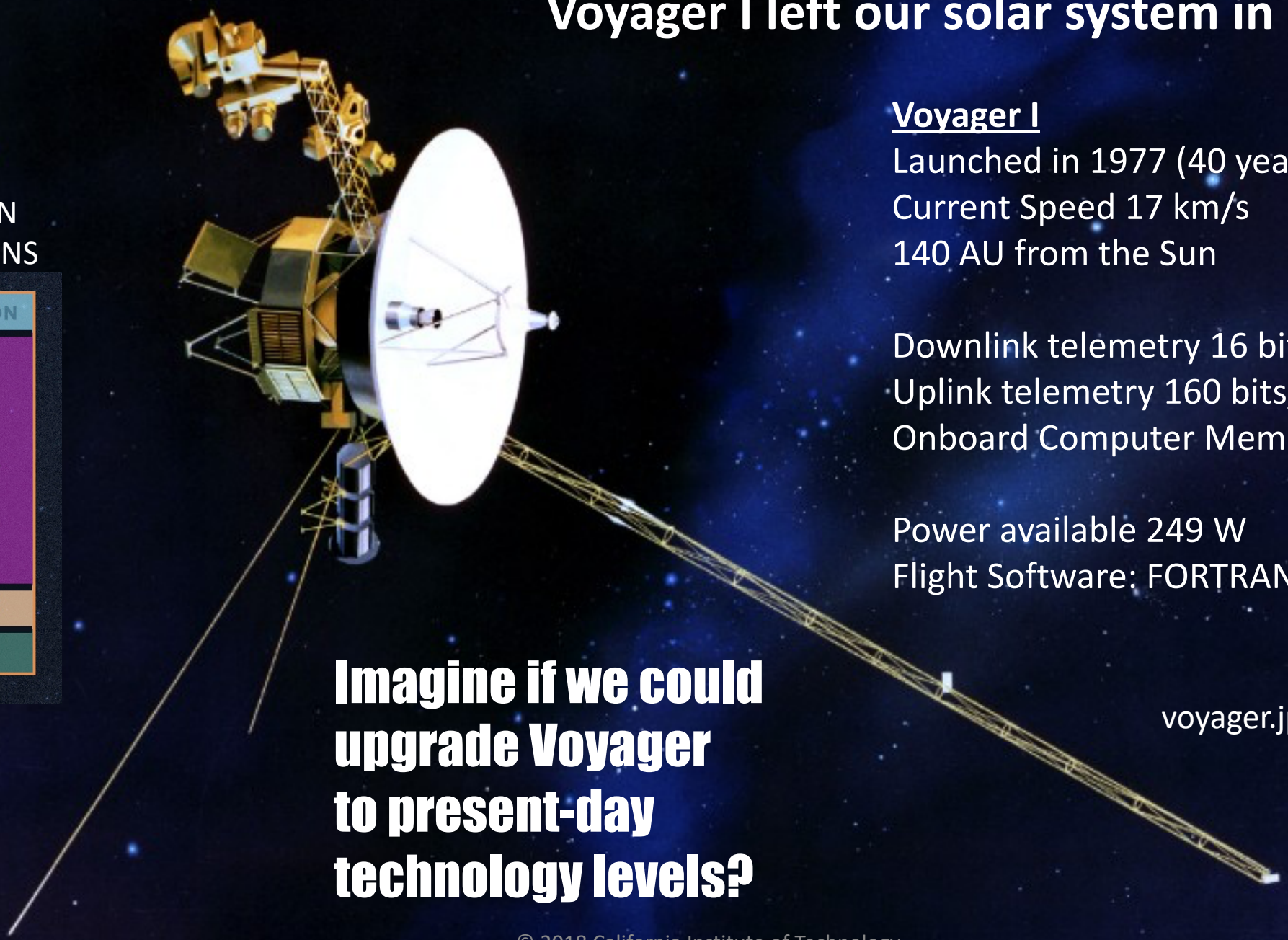


With a lot of help from JPL's A-Team

Voyager I left our solar system in 2012

MISSION FUNCTIONS





Voyager I
Launched in 1977 (40 years ago!)
Current Speed 17 km/s
140 AU from the Sun

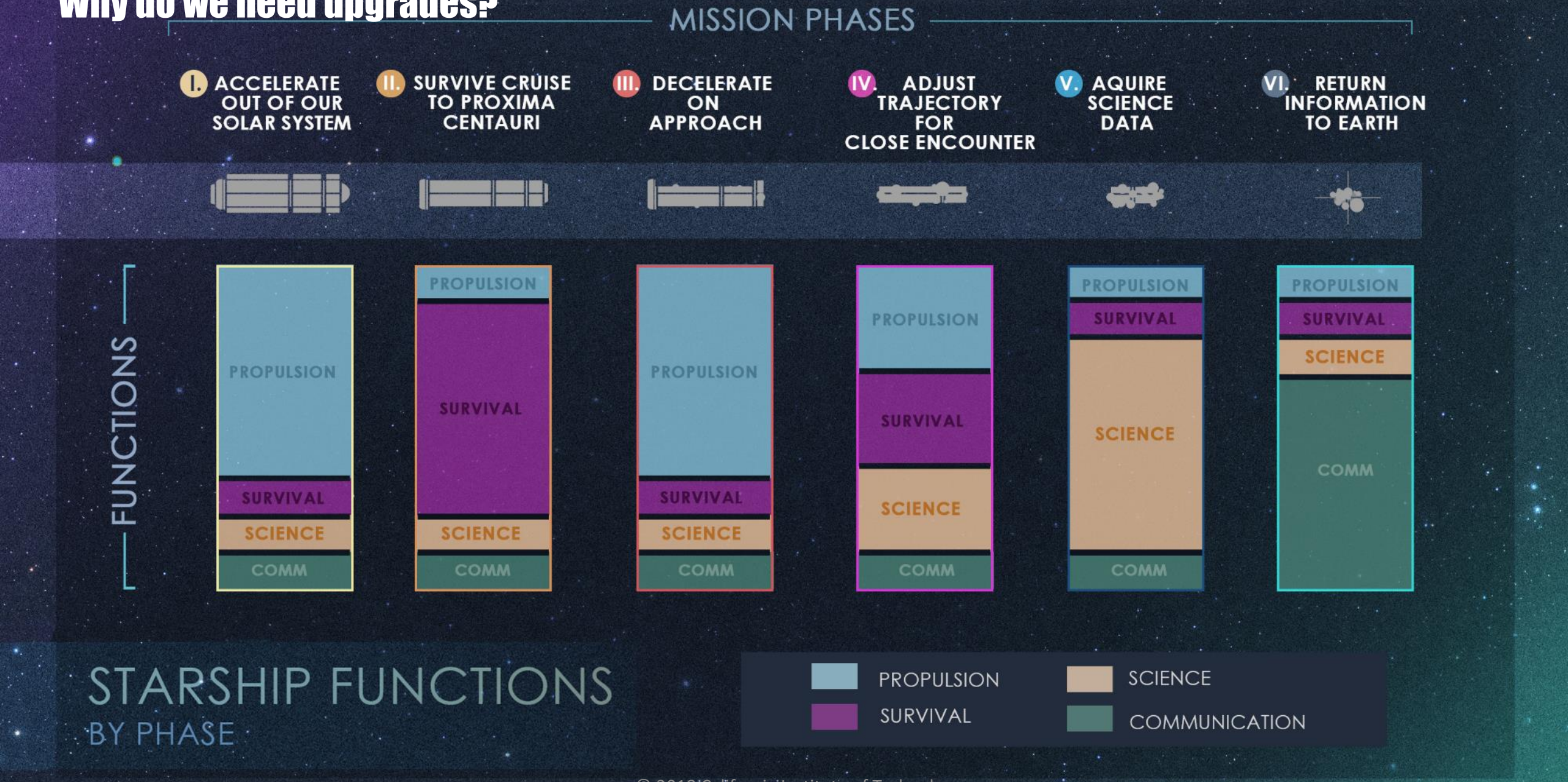
Downlink telemetry 16 bits/sec
Uplink telemetry 160 bits/sec
Onboard Computer Memory 70 kBytes

Power available 249 W
Flight Software: FORTRAN/C

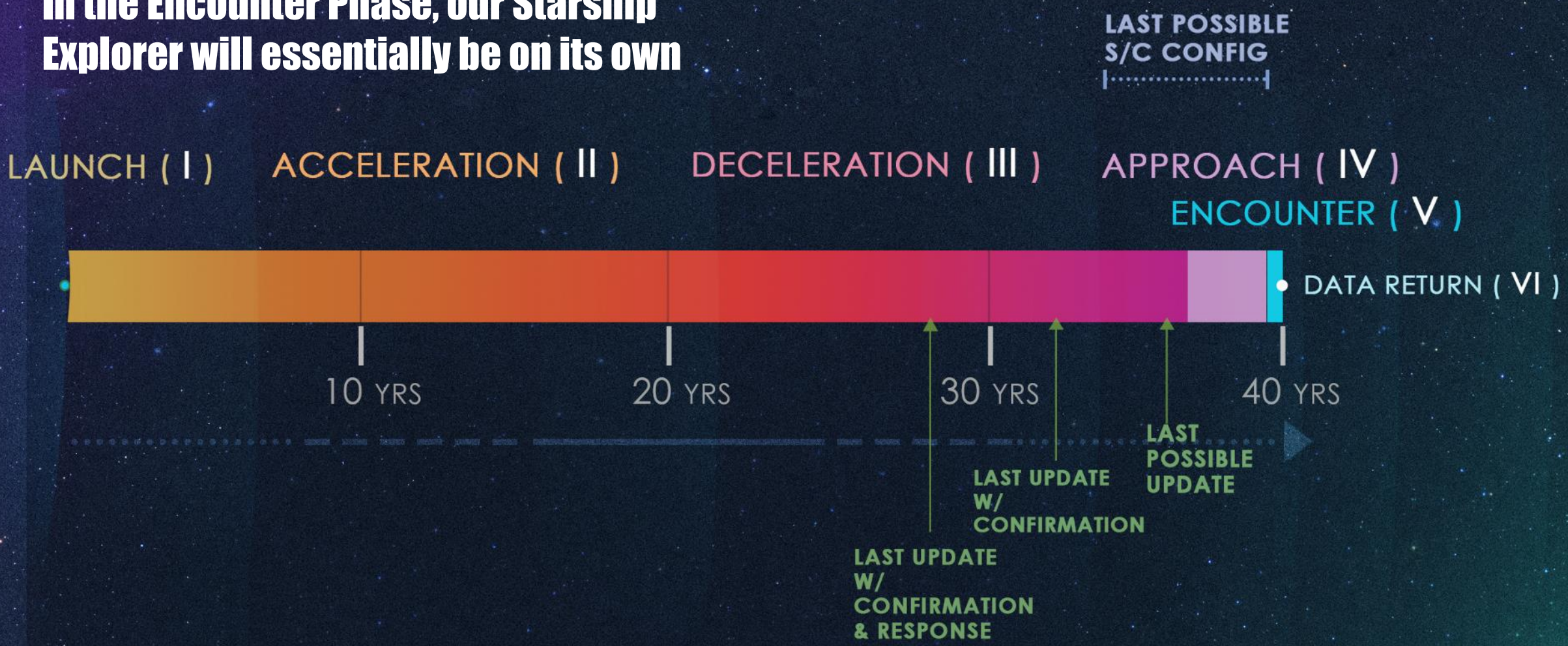
Imagine if we could upgrade Voyager to present-day technology levels?

voyager.jpl.nasa.gov

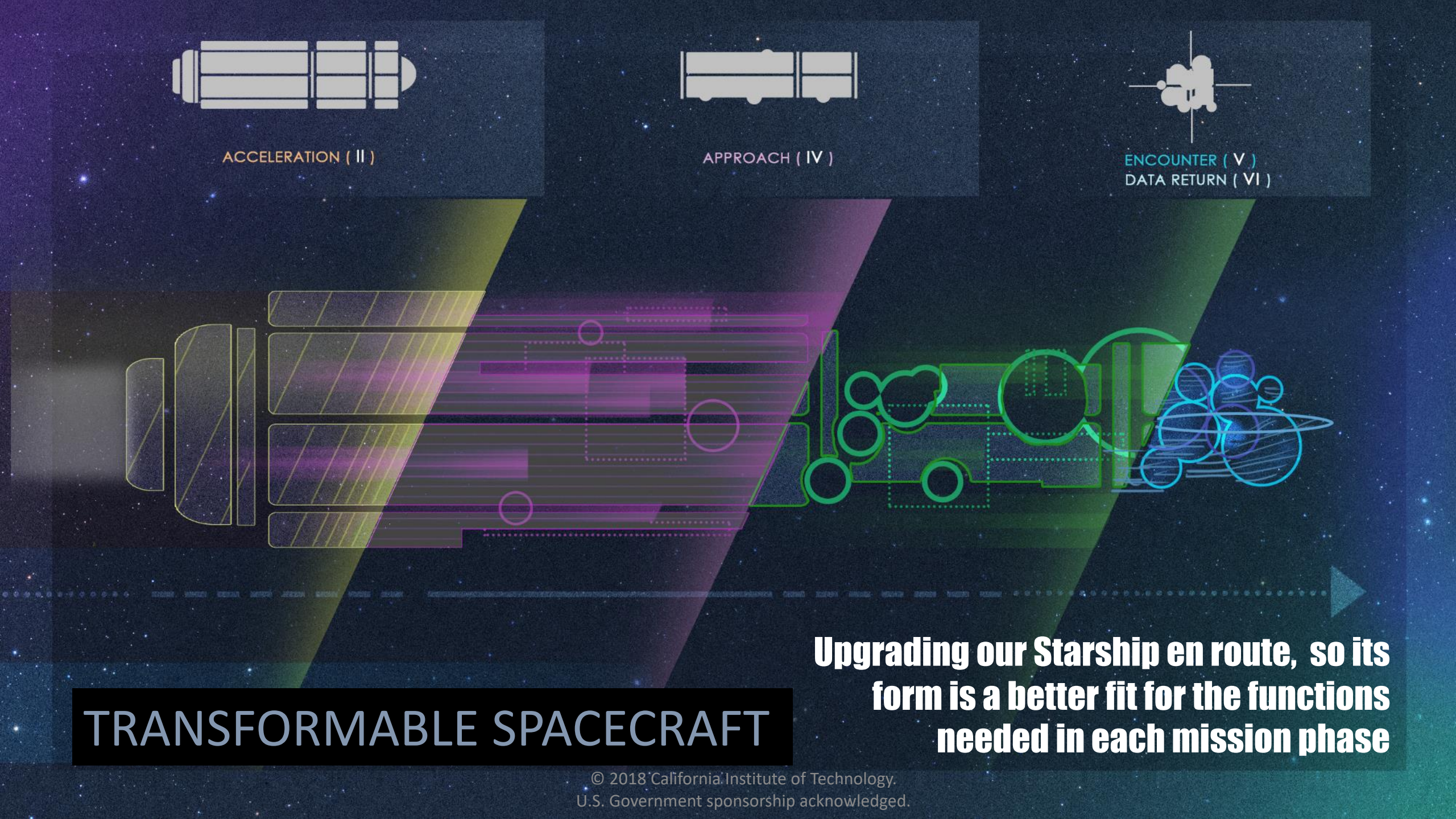
Why do we need upgrades?



In the Encounter Phase, our Starship Explorer will essentially be on its own

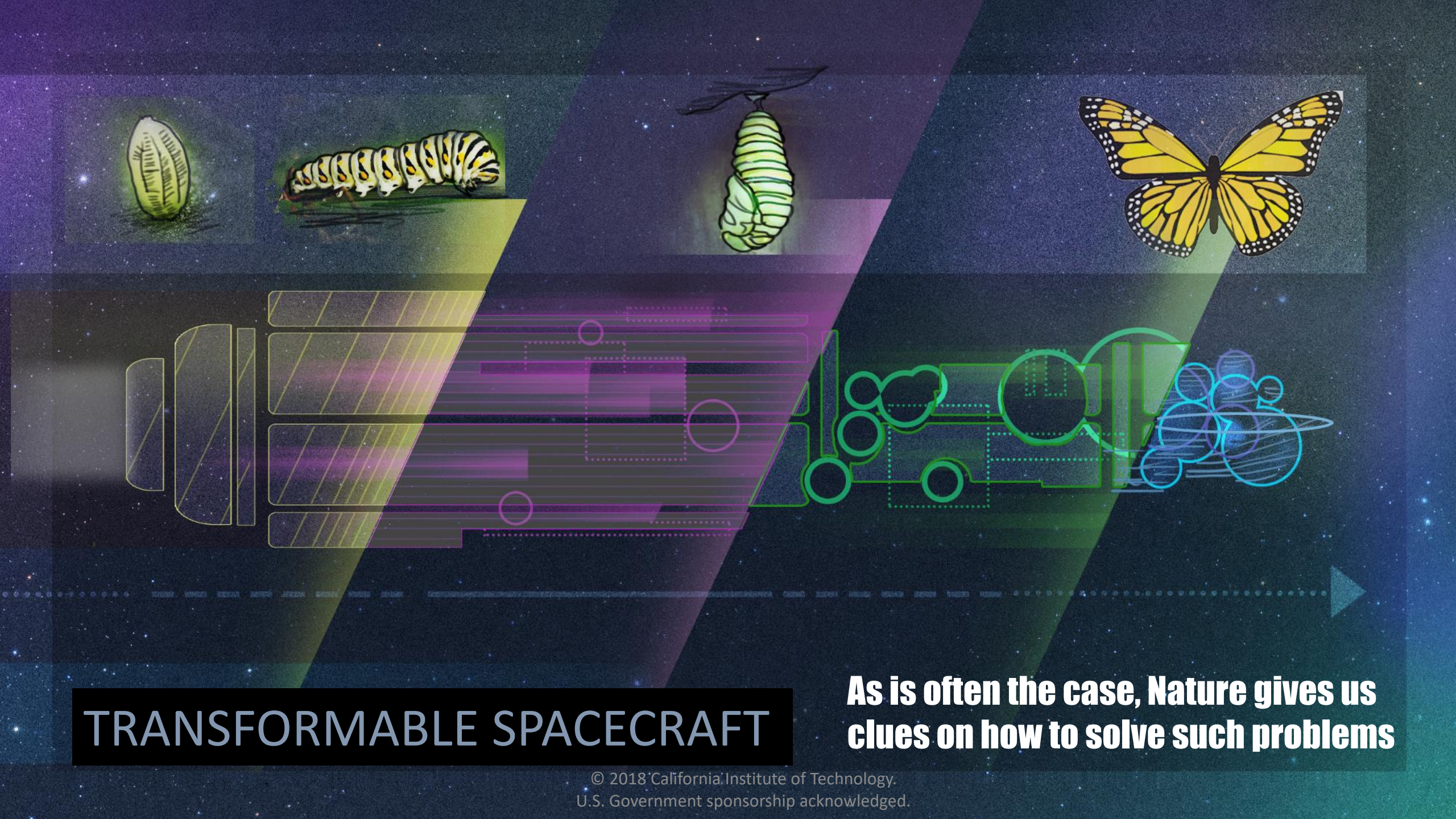


MISSION PHASES AND DECISION POINTS



TRANSFORMABLE SPACECRAFT

Upgrading our Starship en route, so its form is a better fit for the functions needed in each mission phase

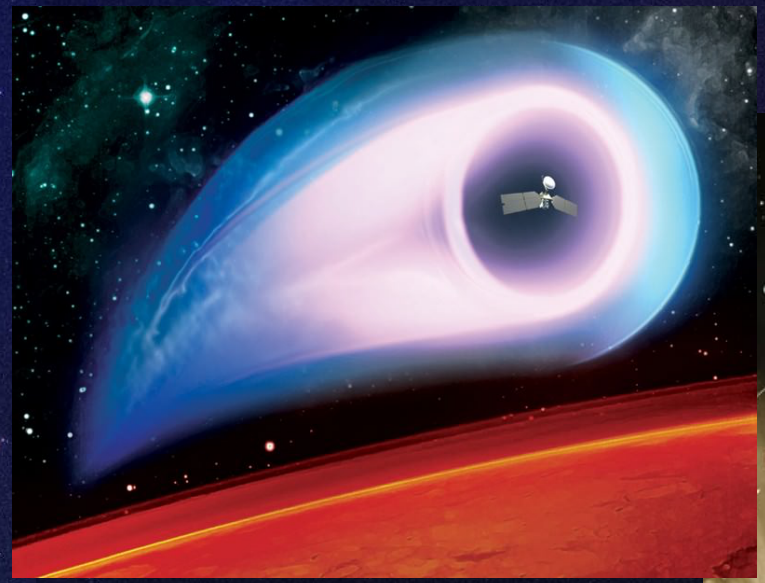


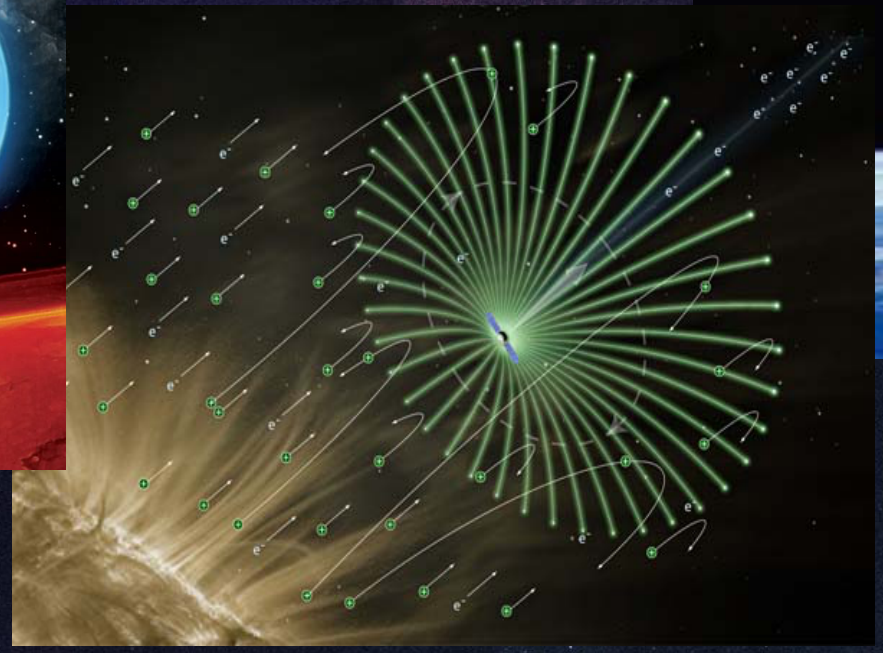
TRANSFORMABLE SPACECRAFT

As is often the case, Nature gives us clues on how to solve such problems

What upgrades might we apply?

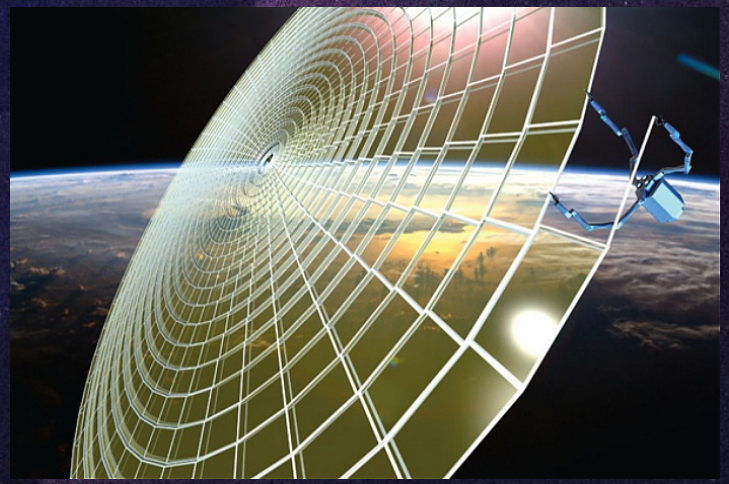
- Power and Propulsion trends to watch:
  - Electromagnetic tethers (Power)
  - Compact Nuclear (Power)
  - E-sails (Propulsion)
  - Magnetoshells (Propulsion)

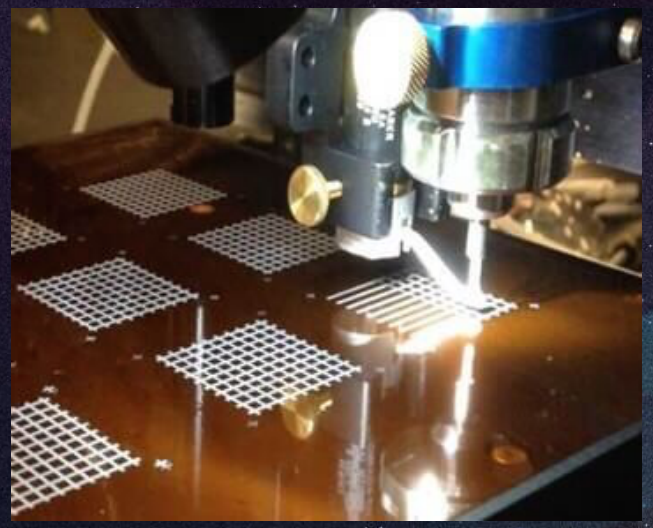


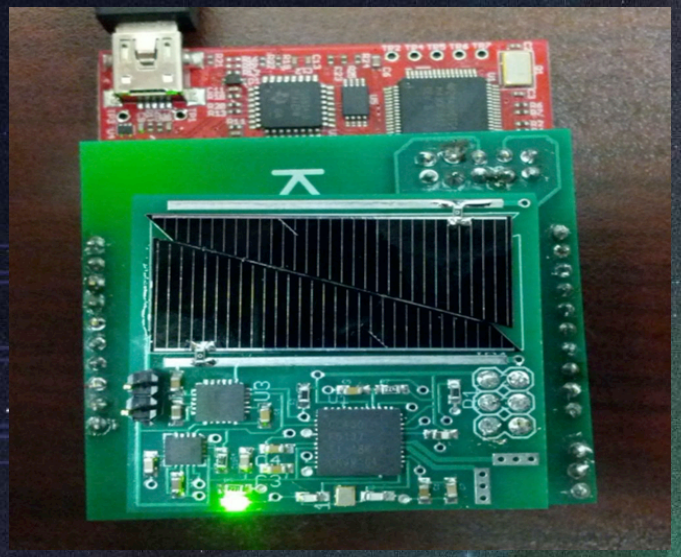


What upgrades might we apply?

- Additive Manufacturing trends to watch:
  - 3D Printing of large structures
  - 3D Printing of sensors and electronics
  - Spacecraft 3-D Printing and Miniaturization
  - Transforming an Asteroid into Spacecraft







FLIGHT HARDWARE UPGRADES @ 4 LY

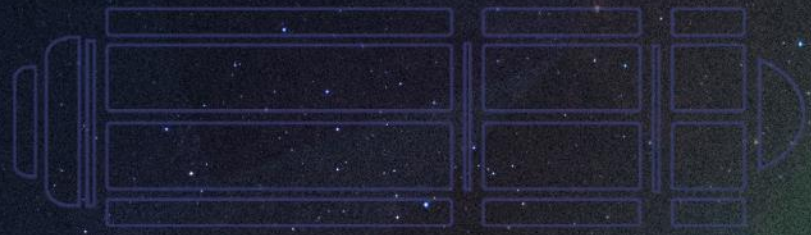
3-D PRINTER

+

MINERAL STOCKS

=

NEW COMPONENTS



FLIGHT HARDWARE UPGRADES @ 4 LY

3-D PRINTER

MINERAL STOCKS

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+

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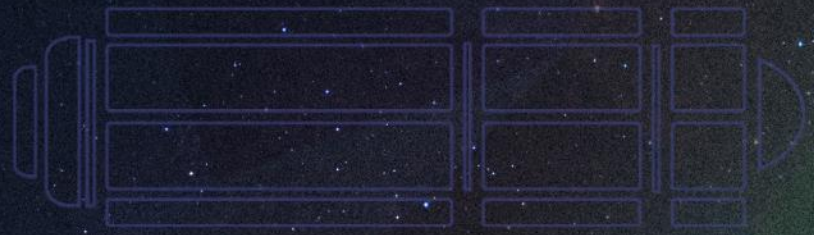

FLIGHT HARDWARE UPGRADES @ 4 LY

3-D PRINTER

\+

MINERAL STOCKS

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NEW COMPONENTS

Tap into the creative juices of the entire world through competitions to design upgrades using limited resources

FLIGHT SYSTEM UPGRADES @ 4 LY

3-D PRINTER

+

MINERAL STOCKS

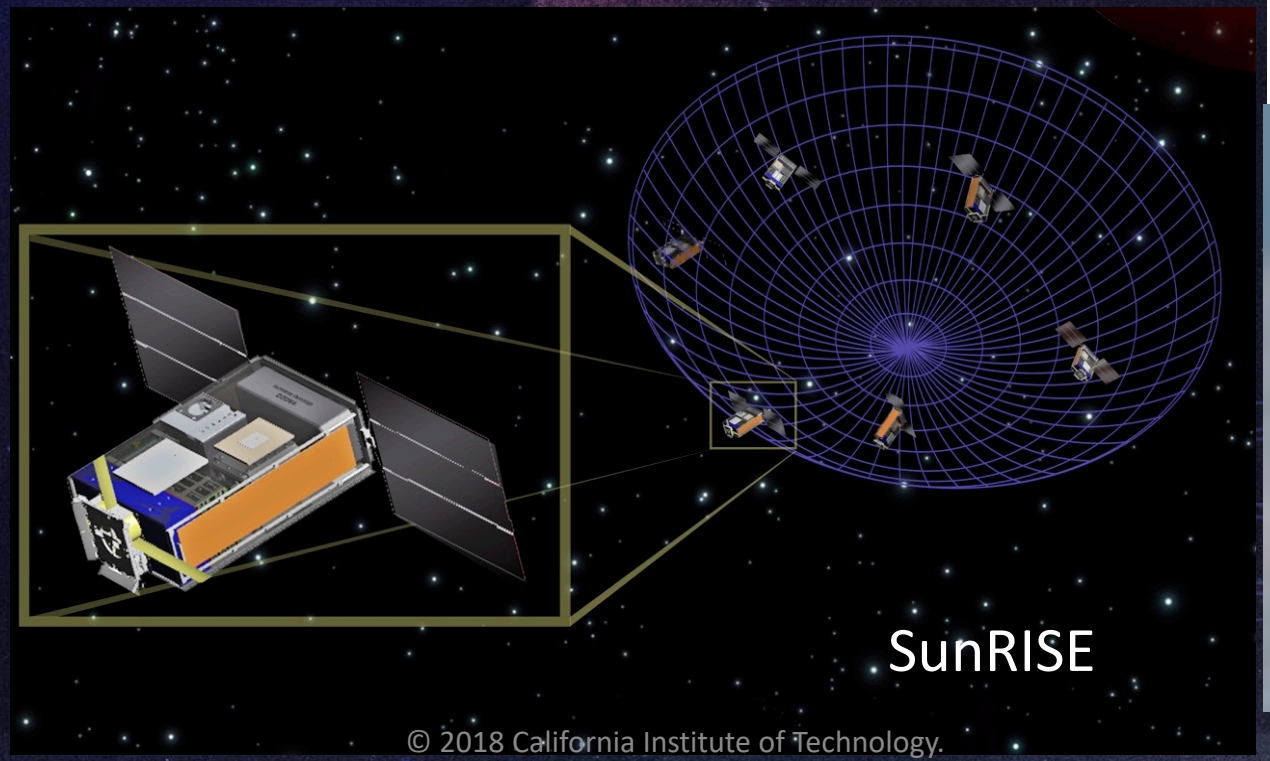
=

NEW COMPONENTS

SOFTWARE

What upgrades might we apply?

- S/W Technology trends to watch:
  - Artificial Intelligence
  - Genetic Programming
  - Autonomous Spaceraft Operations
    - Single S/C
    - Constellations

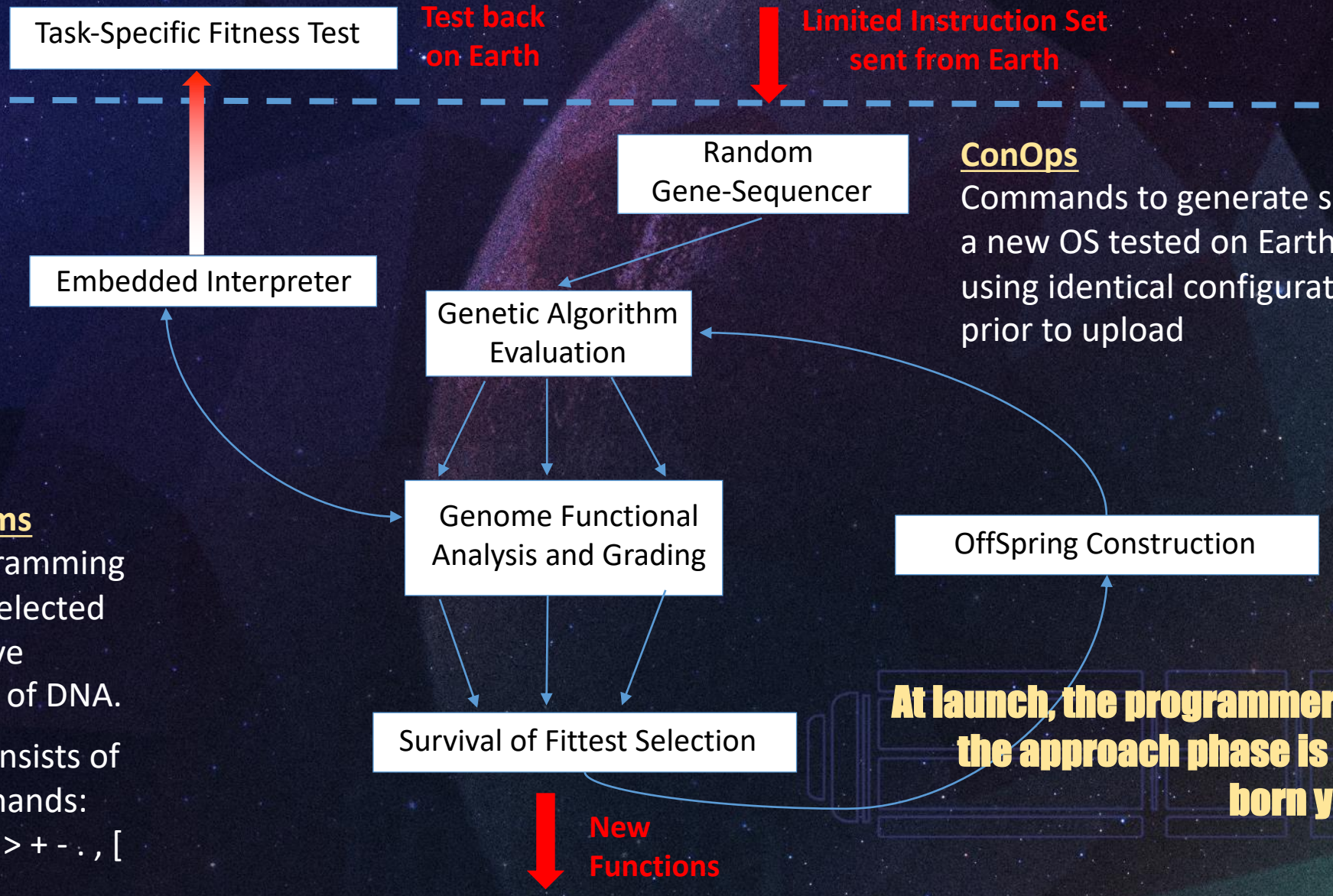


SunRISE

ASTERIA

FLIGHT SOFTWARE UPGRADES @ 4 LY?

AI Programming
- uses genetic algorithms coupled with a tightly constrained programming language that minimizes the overhead of its Machine Learning search space.



ConOps
Commands to generate say a new OS tested on Earth using identical configuration prior to upload

Genetic Algorithms
- A series of programming instructions are selected at random to serve as an initial chain of DNA.

Instruction set consists of just 8 basic commands:

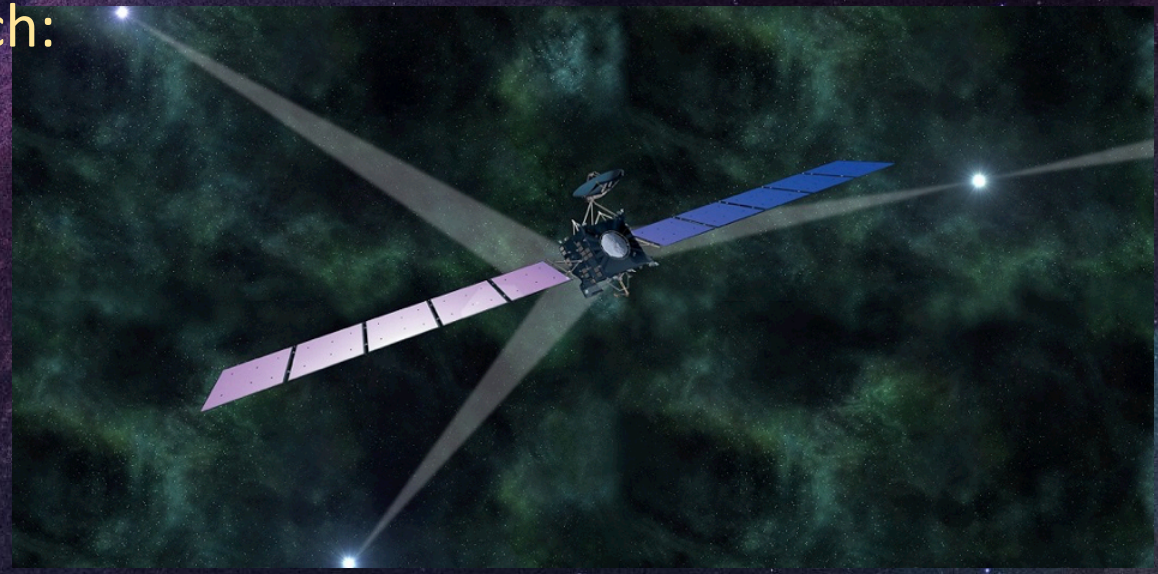
< > + - . , [ ]

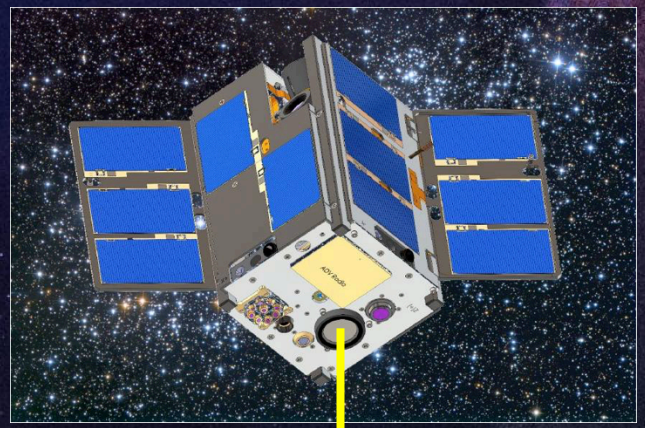
At launch, the programmer for the approach phase is not born yet…

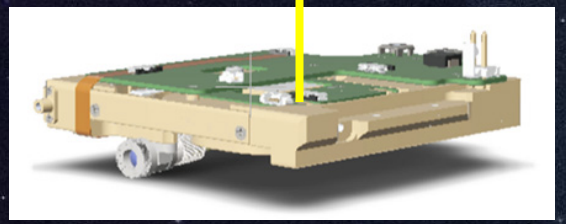
Acknowledgment: Becker, K., and Gottschlich, J., AI Programmer: Autonomously Creating Software Programs Using Genetic Algorithms, arXiv:1709.05703, arXiv.org (2017)

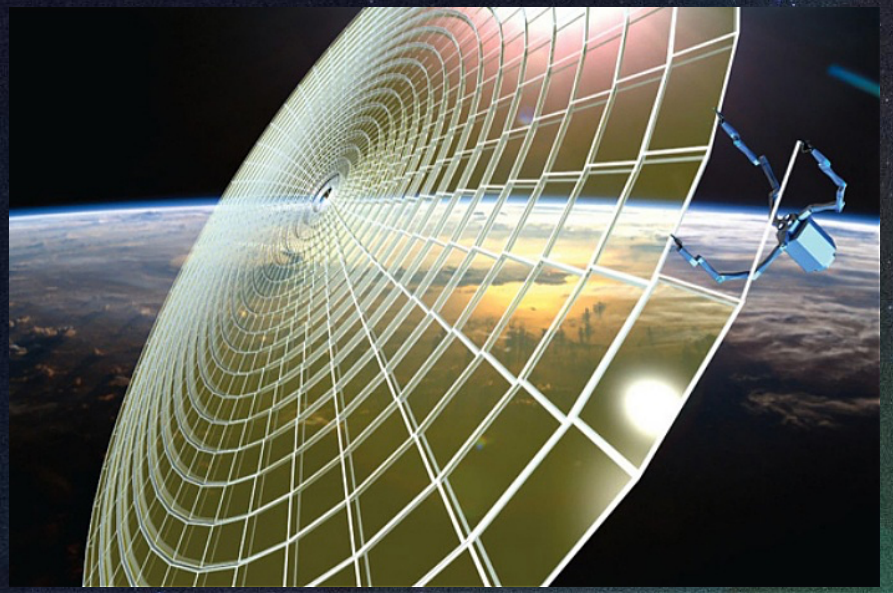
What upgrades might we apply?

- Navigation and Communication trends to watch:
  - Navigation using PulSARs
  - 3-D printing a giant RF antenna
  - Optical Communication









SUPPORT MISSION

EARTH SUN

PRIMARY MISSION

GRAVITY LENS

550 AU

270,000 AU

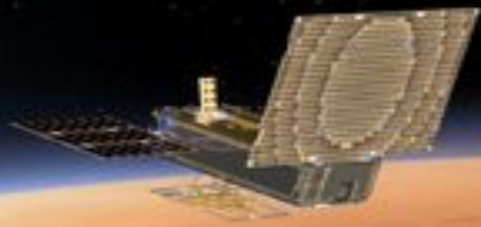
DATA RETURN

OPTICAL COMM* ENHANCED BY GRAVITATIONAL LENSING?

MORE CONVENTIONAL RF? ~~QUANTUM ENTANGLEMENT?~~

*as suggested by John Brophy (A-Team)

FINAL THOUGHTS



If all this sounds a little far-fetched….

- In 2011, interplanetary cubesats were considered a wild idea
- In 2018, JPL's two MarCO cubesats are currently en route to Mars…